



Chemical Security Engagement Program

# Managing a Chemistry Laboratory Safely and Securely

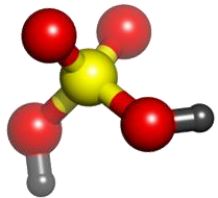
International Conference of Young Chemists  
Amman, Jordan  
9 April 2012



SAND No. 2009-8395P

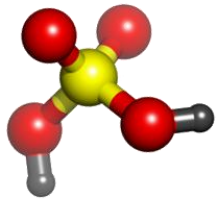
Sandia is a multi-program laboratory operated by Sandia Corporation, a Lockheed Martin Company, for the United States Department of Energy's National Nuclear Security Administration under contract DE-AC04-94AL85000.





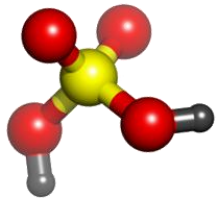
# Workshop Objectives

- ▶ Promote the safe and peaceful use of chemistry
- ▶ Appreciate the importance and benefits of Chemical Safety and Security (CSS)
  - To do top level work, you need top level CSS practices
- ▶ Encourage the creation of networks of people interested in CSS
  - Culture of Chemical Safety and Security



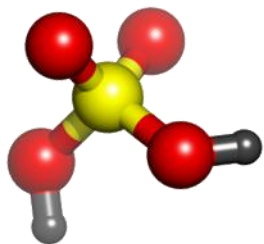
# Workshop Overview

- ▶ Orientation to Chemical Safety and Security (CSS)
- ▶ Fundamentals of CSS
- ▶ Chemical Management
- ▶ Workshop Summary and Conclusions



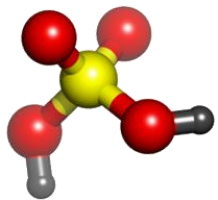
# Introductions

- ▶ Introduce yourself to 2 or 3 people you do not know
  - What is your name?
  - Where are you from?
  - What is your background?
    - Professor or student?
    - Area of expertise?



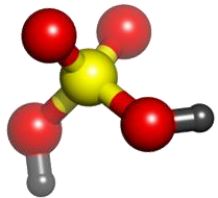
# Orientation to Chemical Safety and Security





# Overview: Orientation to Chemical Safety and Security

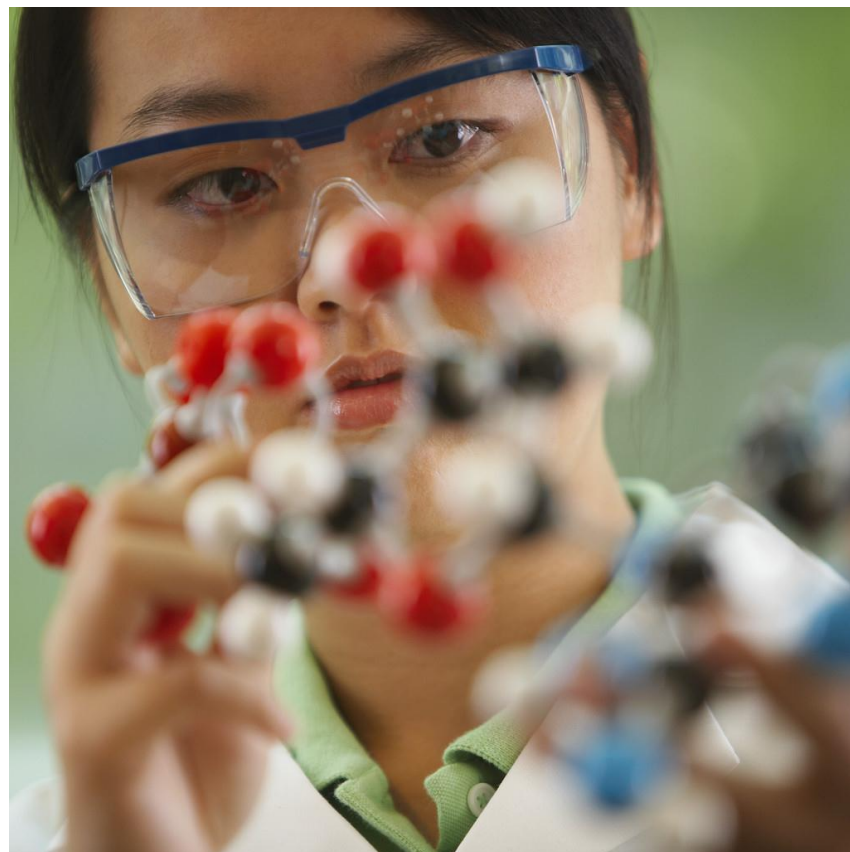
- ▶ Definitions of Chemical Safety and Security (CSS)
- ▶ Activity: Importance of CSS
- ▶ CSS Resources – Introduction to CSP
- ▶ Conclusions

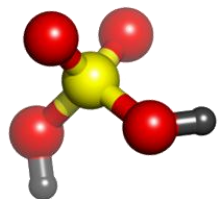


# Chemical Safety and Security (CSS)

- ▶ Chemical Safety
  - Preventing and protecting against chemical laboratory accidents
- ▶ Chemical Security
  - Preventing and protecting against the **intentional misuse** of chemicals, people, or equipment for non-peaceful purposes

Our Goal: **Promote the Safe and Peaceful use of Chemistry**



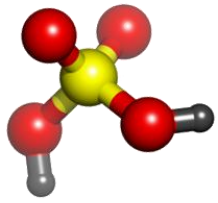


# Activity: Importance of CSS

- ▶ Form groups of 4–5 people per group
- ▶ Discuss with your group to answer the questions:
  1. What are CSS hazards?
  2. Can you think of any well-known examples of CSS incidents?
  3. Who and what are potentially affected?
  4. What are the potential consequences?
  5. How common are CSS incidents?
  6. Have incidents ever happened at your institution or that of someone you know?
- ▶ Write down your answers and be prepared to share with the whole group

Take about 15–20 min





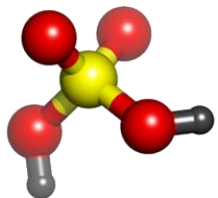
# Activity: Importance of CSS

## 1. What are CSS hazards?

### ► Hazard

- Something that has the potential to do harm
  - Chemical
  - Physical
  - Biological
  - Radiological



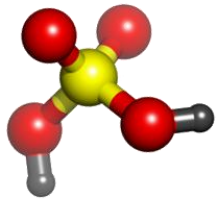


# Activity: Importance of CSS

2. Can you think of any well-known examples of CSS incidents?

- ▶ Sheharbano Sangji
- ▶ Los Angeles, USA 2008
  - Died from fire, *t*-BuLi
  - Inexperienced, proper training in question
  - UCLA Prof. Patrick Harran could face up to 4 ½ years in prison



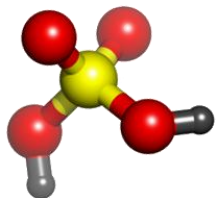


# Activity: Importance of CSS

2. Can you think of any well-known examples of CSS incidents?

- ▶ Aum Shinrikyo
- ▶ Japan 1994–1995
  - Recruited young university scientists
  - Produced sarin and other chemical weapons
  - Killed ~20 and injured over 4000





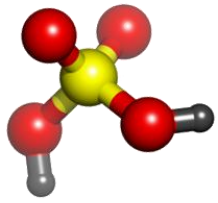
# Activity: Importance of CSS

## 3. Who and What are potentially affected?

- ▶ Laboratory personnel
- ▶ Research
- ▶ Faculty, Administrators, and Institutions
  - Careers
  - Reputations
  - Facilities
- ▶ Community
  - People
  - Relationships with institutions
- ▶ Economy
- ▶ Environment



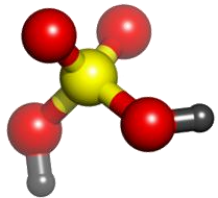




## Activity: Importance of CSS

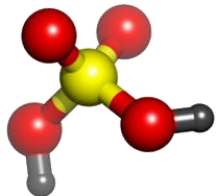
4. What are the potential consequences?
5. How common are CSS incidents?
6. Have incidents ever happened at your institution or that of someone you know?





# Activity: Importance of CSS

- ▶ **Conclusions for Activity**
  - Chemical laboratories have many types of hazards
  - There are many examples of notorious CSS incidents
  - CSS incidents happen too often and can cause severe harm
  
- ▶ **Improving CSS will benefit**
  - Laboratory personnel
  - Research
  - Faculty, Administrators, and Institutions
    - Careers, reputations, facilities
  - Community
  - Economy
  - Environment



# CSS Resources

Home



Log in

[Home](#) [Workshops](#) [Share Your Training](#) [Discussion Board](#) [Resources](#) [Contacts](#)

## About Our Program

### The Chemical Security Engagement Program (CSP) Partners With Chemical Professionals To:

#### Raise Awareness: Dual Use Nature of Chemicals

CSP works to reduce the risk of chemical threats by collaborating with partner governments, national and international chemical organizations, and chemical professionals to raise awareness about chemical security and safety, consistent with national and international guidelines, norms, and requirements.

#### Foster Collaboration among Chemical Professionals Worldwide

CSP works with chemical organizations and universities to facilitate collaboration between chemical professionals. CSP is particularly interested in funding collaboration that can improve laboratory safety and security.

#### Provide Training Opportunities and Technical Assistance to Improve Chemical Safety and Security in Laboratories

CSP seeks to work with chemical universities and professional organizations to develop and implement training modules to reinforce chemical security and safety best practice chemical curricula.

#### Facilities Training and Industrial Partnership to Improve Chemical Security Best Practices in CSP Partners' Local Chemical Industries

CSP partners with chemical industrial organizations to promote established best practices in chemical security, such as those reflected in the Responsible Care® Security Code and Responsible Care Management System. CSP also facilitates membership opportunities for CSP partners' local chemical companies in the area of chemical security.

On a case-by-case basis, CSP also offers assistance with risk assessment for key chemical facilities to help implement chemical security best practices.

## Program Objectives

Decrease chemical threat by:

- Raising threat awareness globally
- Providing assistance to improve chemical safety and security best practices in laboratories


 Search Site 

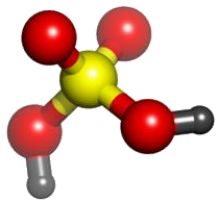

## Chemical Security Engagement Program (CSP)

[www.csp-state.net](http://www.csp-state.net)

- About CSP
- Map of participating countries
- Past and upcoming events
- Photo galleries
- Discussion board
- Access resources
- Contact us

Fill out name, email, and desired username

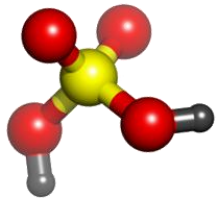
- Will get an email to set your password



# Conclusions: Orientation to Chemical Safety and Security

- ▶ Promote the safe and peaceful use of chemistry
- ▶ Benefits of improving Chemical Safety and Security (CSS) are far-reaching and significant
- ▶ After this workshop, you should be able to
  - Appreciate the importance and benefits of CSS
  - Help create networks of people interested in CSS

**A culture of Chemical Safety and Security requires participation from everyone!**



# Workshop Overview

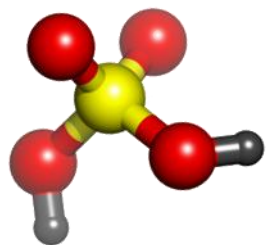
☑ Orientation to Chemical Safety and Security (CSS)

- ▶ **Fundamentals of CSS**

- Hazards
- Controls

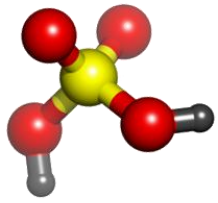
- ▶ Chemical Management

- ▶ Workshop Conclusions



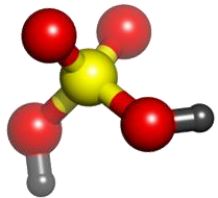
# Fundamentals of Chemical Safety and Security





# Overview: Fundamentals of Chemical Safety and Security

- ▶ Laboratory Hazards
  - Chemical
  - Physical
  - Biological
  - Radiological
- ▶ Globally Harmonized System (GHS) Hazard Labels
- ▶ GHS Safety Data Sheets (SDS)
- ▶ Hierarchy of CSS Controls
- ▶ Conclusions



# Laboratory Hazards



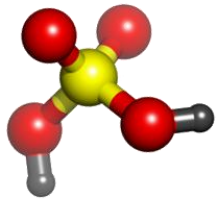
## ▶ Chemical Hazards

- Toxic
  - Principles of Toxicity
  - Acute Toxins
  - Irritants, Corrosives, and Allergens
  - Organ-targeting
  - Carcinogens
- Flammable
- Reactive
- Explosive
- Chemicals of Concern (COCs)

## ▶ Physical Hazards

## ▶ Biological Hazards

## ▶ Radiological Hazards



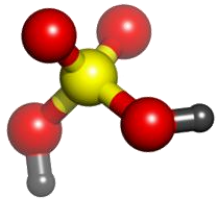
# Chemical Hazards: Principles of Toxicity

## Toxicity Depends on Dose

<u>Chemical</u>	<u>Beneficial Dose</u>	<u>Toxic Dose</u>
Aspirin	300–1 000 mg	1 000–30,000 mg
Vitamin A	500 units/d	50,000 units/d
Oxygen	20% in air	50–100% in air
Water	~1-2 L/day	~13 L

“All substances are poisons; there is none which is not a poison. The right dose differentiates a poison from a remedy.”

– Paracelsus (1493–1541)



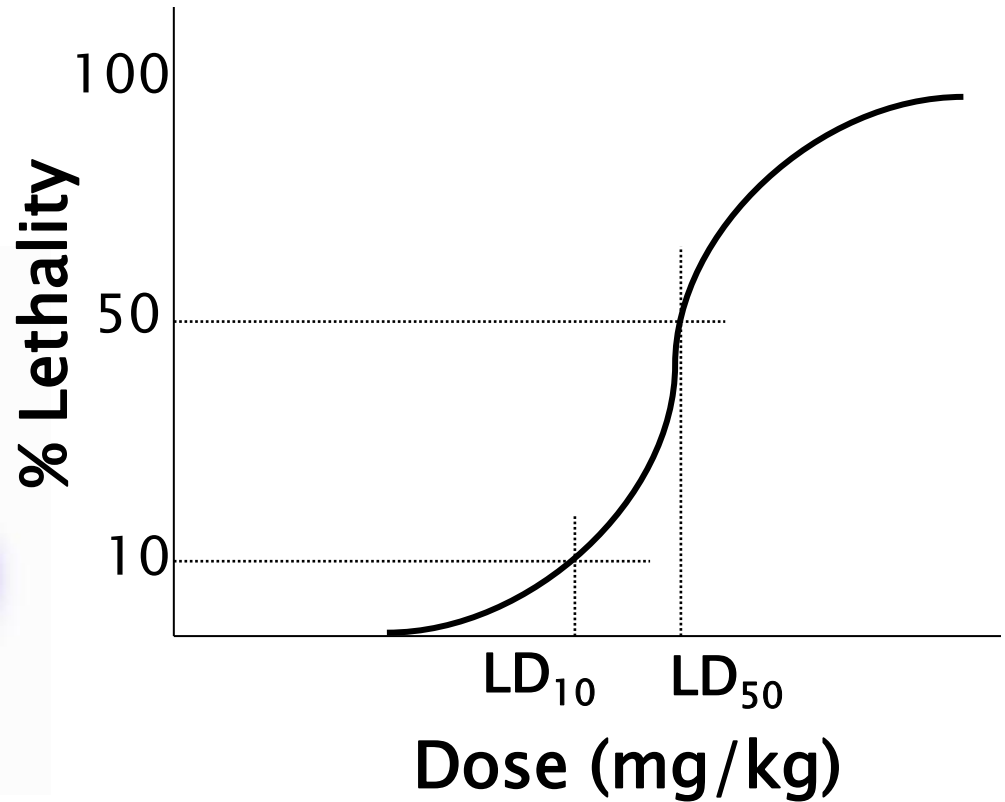
# Chemical Hazards: Principles of Toxicity

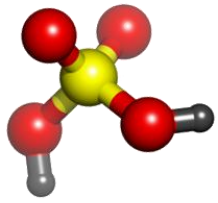
## Toxicity is Measured by Lethality

- $LD_{50}$  (mg/kg)
- “Lethal Dose 50%”



## Dose-Response Curve





# Chemical Hazards: Principles of Toxicity

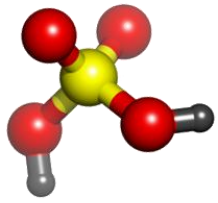
- ▶ Extremely wide range of toxicities between different substances

Agent	LD <sub>50</sub> (mg/kg)
Ethanol	7060
NaCl	3000
Formaldehyde	800
Caffeine	192
Nicotine	1
Dioxin	0.0001



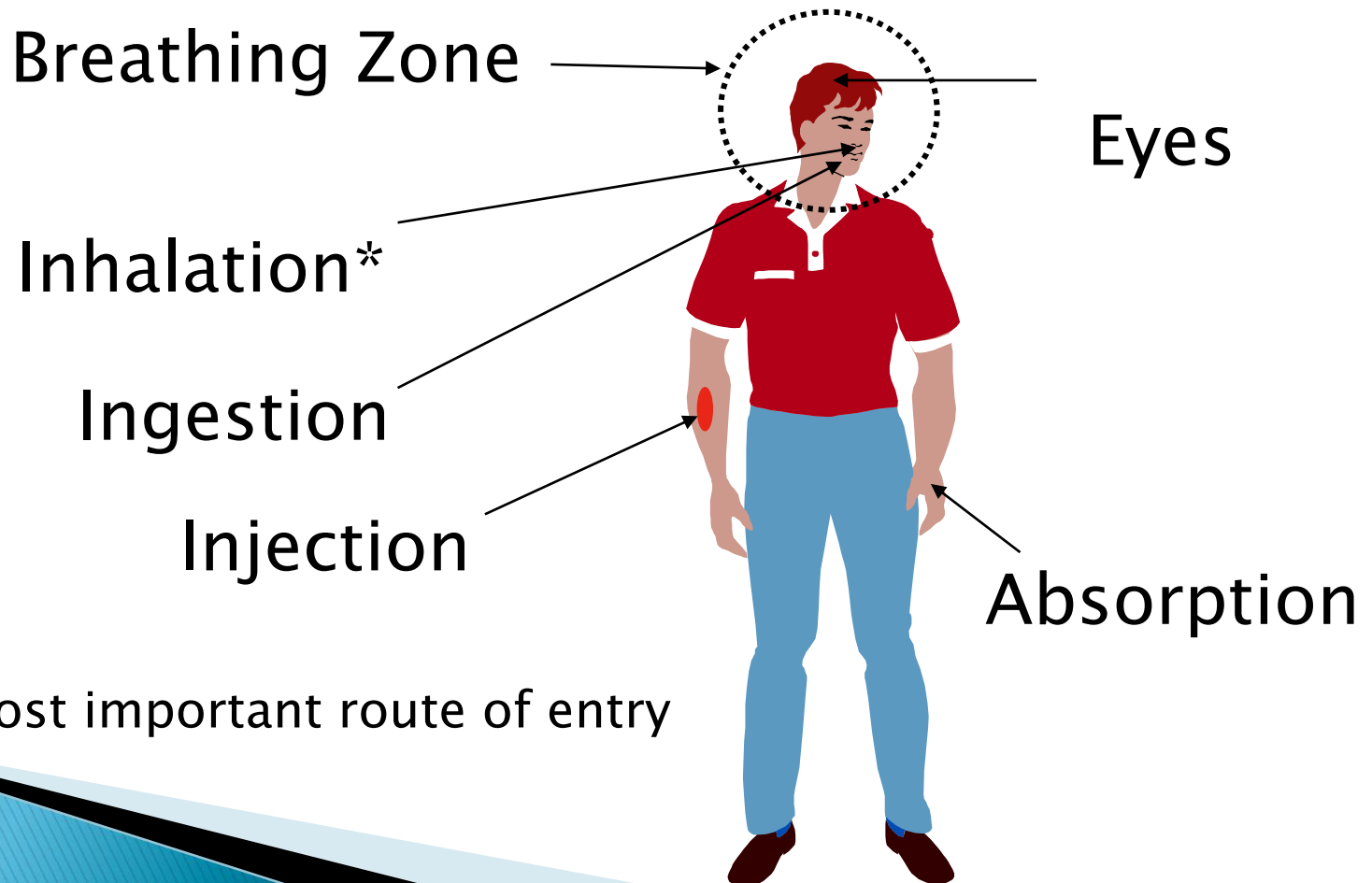
**Toxicity depends on  
a variety of factors**

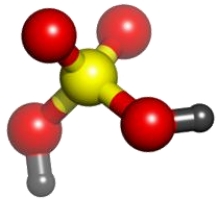




# Chemical Hazards: Principles of Toxicity

## Routes of Exposure

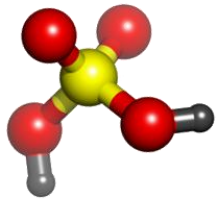




# Chemical Hazards: Principles of Toxicity

- ▶ Acute
  - Cause harm right away
  
- ▶ Chronic
  - May only see effects after extended exposure, or later in life after repeated exposures



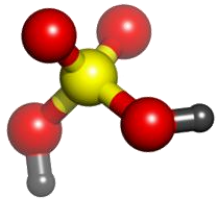


# Chemical Hazards: Acute Toxins

- ▶ Includes highly toxic chemicals/poisons
  - Phosgene
  - Strychnine
- ▶ Includes common lab chemicals
  - Cyanides
  - $\text{Cl}_2$

**Need to ensure safety and security when using and storing acute toxins**





# Chemical Hazards: Irritants, Allergens, and Corrosives

## ▶ Irritants

- Effects are local and reversible



## ▶ Corrosives

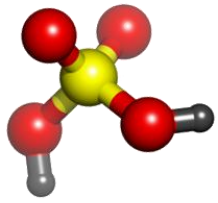
- Effects are local
- Acids and bases
  - $\text{pH} \leq 2$  or  $\geq 12.5$
- React with and damage living tissue



## ▶ Allergens (and sensitizers)

- Cause a reaction of the immune system





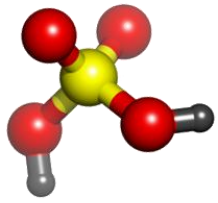
# Chemical Hazards: Organ-Targeting



- ▶ Neurotoxins
  - Ethanol, Hg, CS<sub>2</sub>, xylene, *n*-hexane
- ▶ Reproductive and Developmental Toxins
  - Harm fertility or reproductive ability
  - Harm fetus
- ▶ Other Organs
  - Liver, kidneys, lungs, etc.
  - Chlorinated or aromatic hydrocarbons, some metals



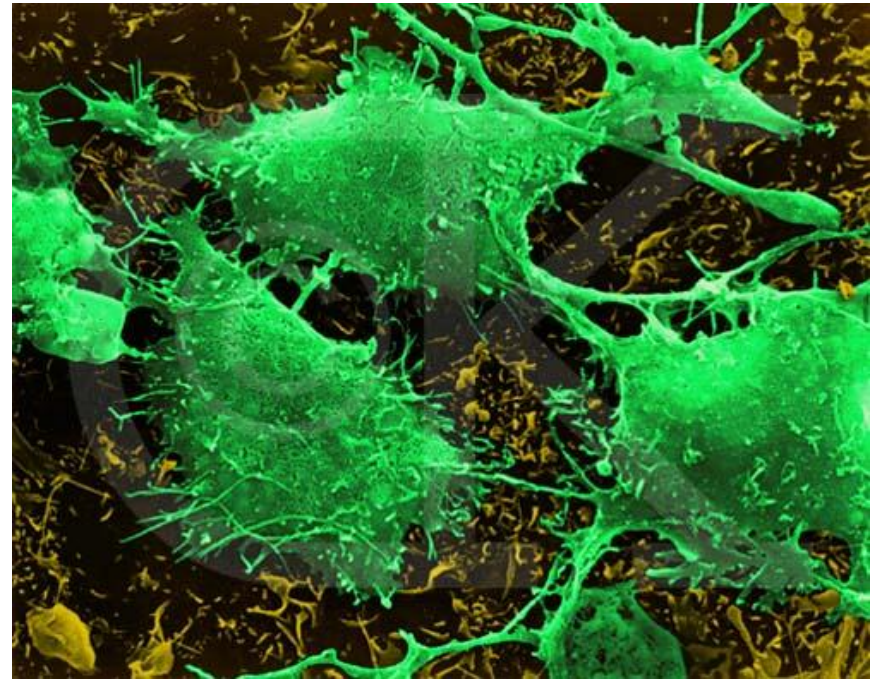




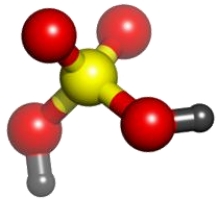
# Chemical Hazards: Carcinogens



- ▶ Chronically Toxic
  - Vinyl chloride (liver cancer)
  - Asbestos (mesothelioma)
- ▶ Carcinogenicity of most chemicals is untested
  - Precautions taken may consider amount and frequency of use
- ▶ Treat known carcinogens as particularly hazardous



[http://www.alternative-cancer.net/images/Cancer\\_cell,%20brain.jpg](http://www.alternative-cancer.net/images/Cancer_cell,%20brain.jpg)

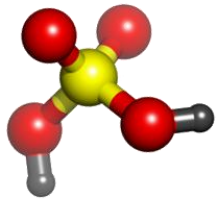


# Chemical Hazards: Flammable

- ▶ Fuel: Solids, Liquid, or Gases
  - Compressed or liquefied gases are especially hazardous
- ▶ Oxidant
  - Oxygen in air
  - Other oxidants
    - $\text{Cl}_2$ ,  $\text{HNO}_3$
- ▶ Ignition
  - Spark
  - Heat



- ▶ University of California, Santa Cruz, 2002
  - Lab fire, cause not determined
  - Lost equipment, notes, samples, etc.
  - Labs took 2 years to reopen

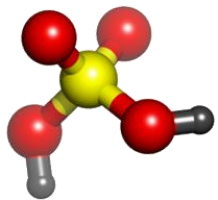


# Chemical Hazards: Reactive

- ▶ Water-reactive
- ▶ Pyrophoric materials
- ▶ Incompatible Chemicals
  - Combination leads to reactive or toxic hazards
    - Concentrated oxidizing or reducing agents





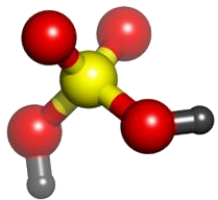


# Chemical Hazards: Explosive

- ▶ Initiated by
  - Heat
  - Light
    - $\text{H}_2 + \text{Cl}_2$
  - Mechanical shock
    - Nitro, peroxo
  - Certain catalysts
    - Acid/base catalyzed polymerization
- ▶ Dusts
- ▶ Peroxide-formers
  - Dialkyl ethers



- ▶ Texas Tech University Chemistry Lab, 2010
  - Synthesis of explosive compound
    - Scaled-up without precautions
    - One graduate student severely injured



# Chemical Hazards: Chemicals of Concern (COCs)

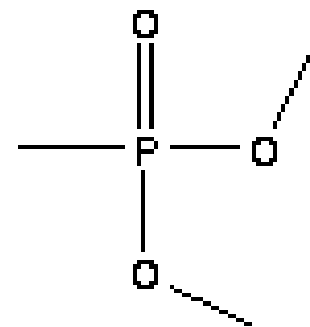
## ► Dual-Use

- Peaceful
  - Research, production
- Not peaceful
  - Diversion, sabotage

## Examples:

### 1. Dimethyl methyl phosphonate (DMMP)

- Flame retardant
- Nerve agent precursor

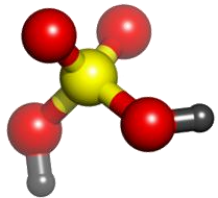


### 2. Thiodiglycol

- Dyes/inks, cosmetics, pharmaceuticals, polymers, coatings, etc.
- Mustard gas precursor







# Chemical Hazards: Chemicals of Concern

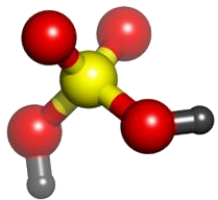
- ▶ Presence or suspected presence of COCs in your laboratory could make you and your institution a target
  - Outsider Threat
  - Insider Threat

## Example: Outsider Threat

- ▶ Chicago, USA, 2002
  - Joseph Konopka arrested in tunnels under the University of Illinois
  - Had NaCN on him and a stockpile of stolen chemicals including NaCN and KCN in subway
  - Sentenced to 13 years in prison for “possessing a chemical weapon” and other charges

[http://articles.cnn.com/2002-03-12/us/chicago.cyanide\\_1\\_cyanide-in-chicago-subway-sodium-cyanide-chicago-police?\\_s=PM:US](http://articles.cnn.com/2002-03-12/us/chicago.cyanide_1_cyanide-in-chicago-subway-sodium-cyanide-chicago-police?_s=PM:US)

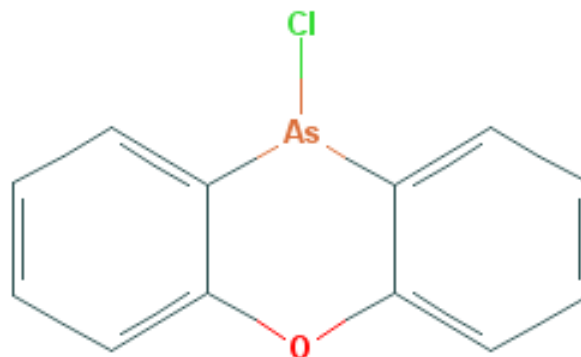
[http://articles.chicagotribune.com/2004-01-04/features/0401040453\\_1\\_tunnels-urban-exploration-city-hall](http://articles.chicagotribune.com/2004-01-04/features/0401040453_1_tunnels-urban-exploration-city-hall)



# Chemical Hazards: Chemicals of Concern

## Example: Insider Threat

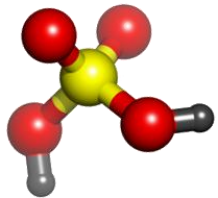
- ▶ Philadelphia, USA, 2007
  - Carol Anne Bond, microbiologist
  - Stole 10-chlorophenoxyarsine from work
  - Attempted to poison her husband's lover
  - Case is still in court



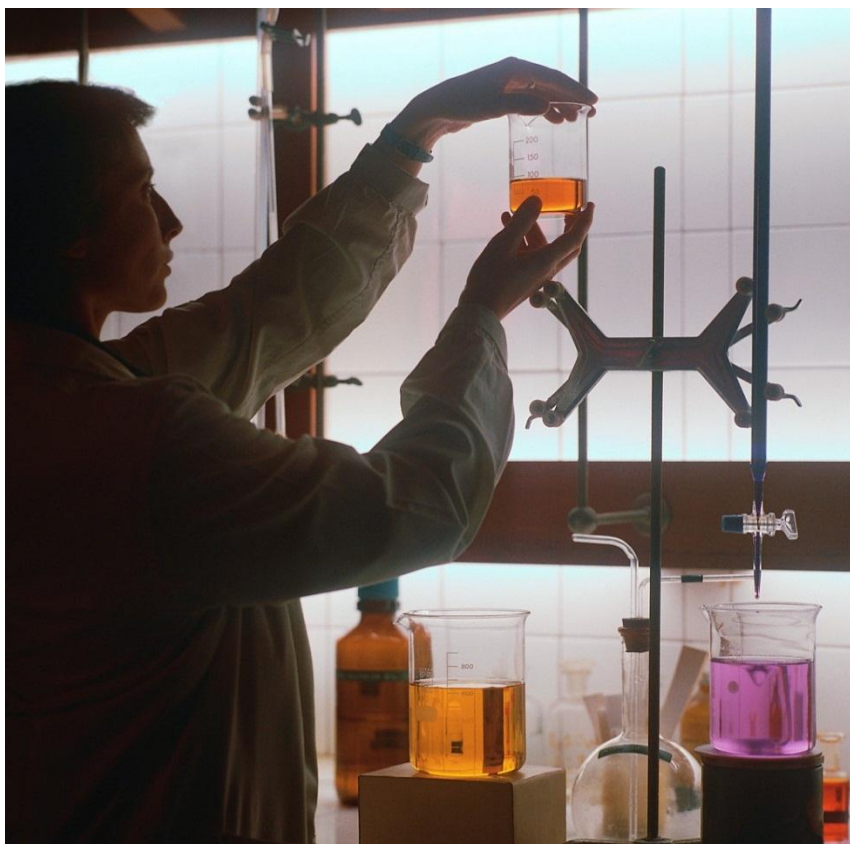
**It is important to recognize the safety and security hazards posed by chemicals**

[http://articles.cnn.com/2011-06-16/justice/us.scotus.poisoned.paramour\\_1\\_potassium-dichromate-mylinda-haynes-carol-anne-bond?\\_s=PM:CRIME](http://articles.cnn.com/2011-06-16/justice/us.scotus.poisoned.paramour_1_potassium-dichromate-mylinda-haynes-carol-anne-bond?_s=PM:CRIME)

<http://www.chemindustry.com/chemicals/0437452.html>



# Laboratory Hazards



## ☑ Chemical Hazards

### ☑ Toxic

- ☑ Principles of Toxicity
- ☑ Acute Toxins
- ☑ Irritants, Corrosives, and Allergens
- ☑ Organ-targeting
- ☑ Carcinogens

### ☑ Flammable

### ☑ Reactive

### ☑ Explosive

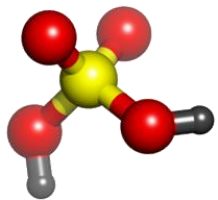
### ☑ Chemicals of Concern (COCs)

## ▶ Physical Hazards

- Compressed gases
- Cryogenics, Pressure, and Temperature
- Electrical
- Mechanical and Other

## ▶ Biological Hazards

## ▶ Radiological Hazards



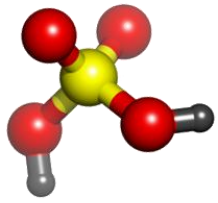
# Physical Hazards: Compressed Gases



- ▶ Pressure
- ▶ Also chemical hazard depending on gas
  - Toxic
  - Reactive
  - Flammable
- ▶ Asphyxiation







# Physical Hazards: Cryogenics, Pressure, and Temperature

## ► Cryogenics

- Dry ice
- Liquid nitrogen
  - Contact
  - Oxygen condensation
  - Asphyxiation
  - Pressure

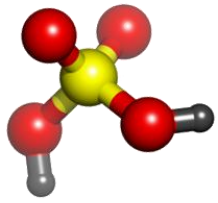
## ► Pressure

- High, above ~1 atm
- Vacuum work

## ► Temperature



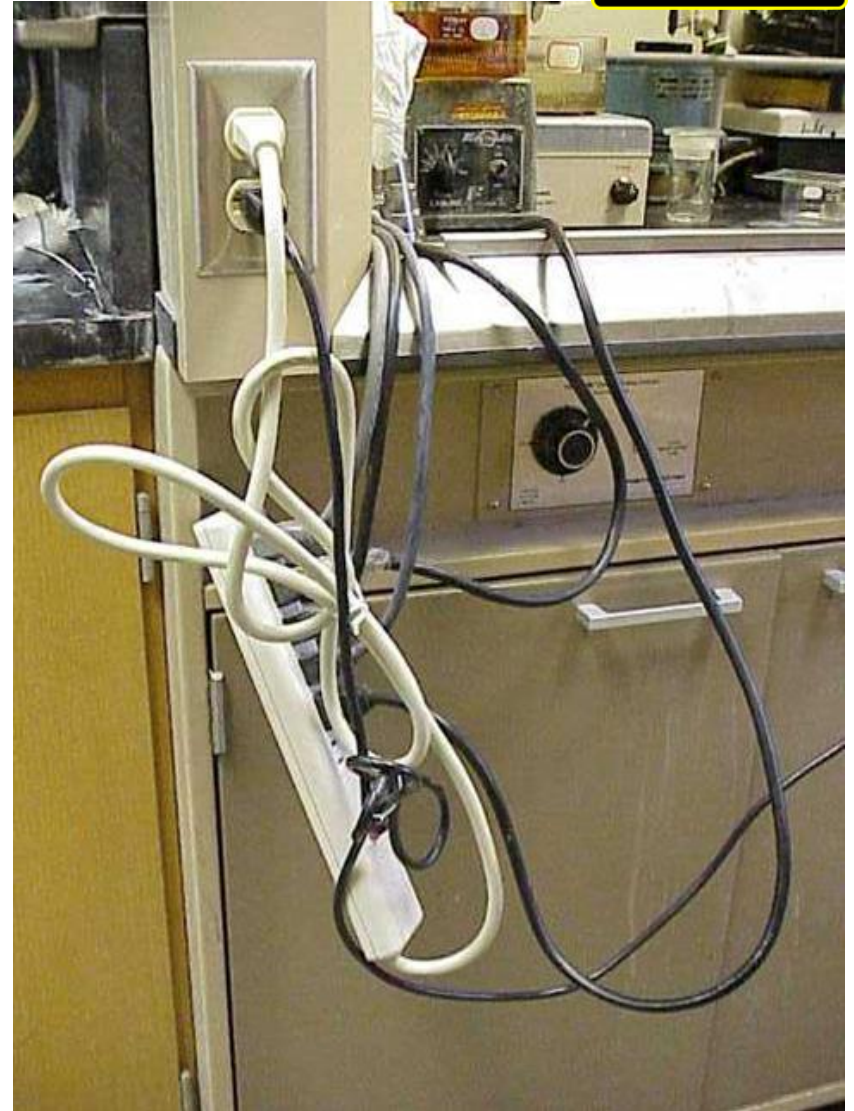


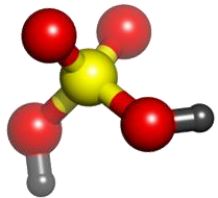


# Physical Hazards: Electrical



- ▶ Power outages
- ▶ Shock
- ▶ Fire
  
- ▶ Frayed cords
- ▶ Overloaded circuits
  - Daisy chains
- ▶ Static electricity





# Physical Hazards: Mechanical and Other



## ▶ Mechanical

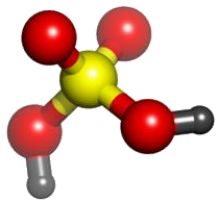
- Noise
- Moving parts
  - Yale University, 2011
    - Student dies after getting hair caught in lathe (machine shop of chemistry lab)

## ▶ Other

- Sharps
- Slips, trips, falls
- Housekeeping
  - Fire
  - Blocked exits



<http://www.waterfront-woods.com/Projects/Lathe/lathe1.JPG>



# Laboratory Hazards



## ☑ Chemical Hazards

### ☑ Toxic

- ☑ Principles of Toxicity
- ☑ Acute Toxins
- ☑ Irritants, Corrosives, and Allergens
- ☑ Organ-targeting
- ☑ Carcinogens

### ☑ Flammable

### ☑ Reactive

### ☑ Explosive

### ☑ Chemicals of Concern (COCs)

## ☑ Physical Hazards

### ☑ Compressed gases

### ☑ Cryogenics, Pressure, and Temperature

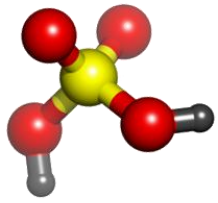
### ☑ Electrical

### ☑ Mechanical and Other

## ▸ Biological Hazards

## ▸ Radiological Hazards



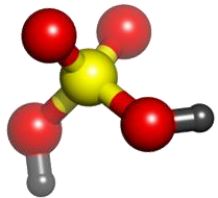


# Laboratory Hazards: Biological

## Pathogens

- ▶ Route of infection
  - Food or water borne
    - Salmonella
  - Blood borne
    - Hepatitis, HIV
  - Airborne
    - Tuberculosis
- ▶ Reason for exposure
  - Diagnostic work
  - Research work





# Laboratory Hazards: Radiological

## ▶ Ionizing Radiation

- X-rays
- Gamma rays
- Alpha particles
- Beta particles
- Neutrons

## ▶ Ionizing Radiation Sources

- Radioactive isotopes
  - $^3\text{H}$ ,  $^{14}\text{C}$ ,  $^{32}\text{P}$ ,  $^{35}\text{S}$ ,  $^{131}\text{I}$
- Instruments
  - Diffractometer
  - Electron microscope

## ▶ Nonionizing Radiation

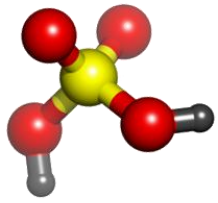
- Ultraviolet
- Infrared



- Primarily an eye hazard

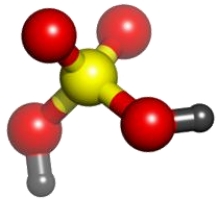










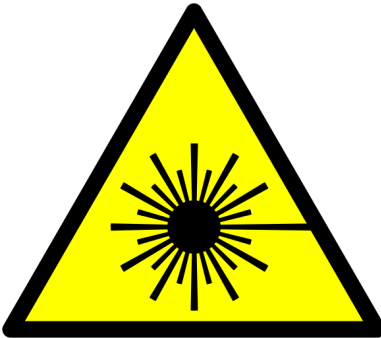



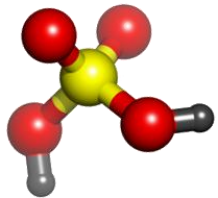
# Globally Harmonized System (GHS) Hazard Labels

<p>Corrosive</p>	<p>Irritant</p>	<p>Health Hazard</p>	<p>Acute Toxicity</p>
<p>Flammable</p>	<p>Explosion</p>	<p>Oxidizer</p>	<p>Compressed Gas</p>



# Globally Harmonized System (GHS) and Other Hazard Labels

Environmental 	Electricity 	Hot Surface 	Pinch Point 
Biohazard 	Radioactive 	Bright Light 	



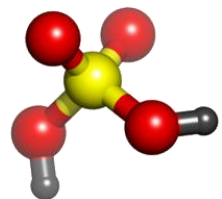
# GHS Safety Data Sheets (SDS)

- ▶ Comprehensive information for chemical management
- ▶ Use GHS hazard symbols
- ▶ Written and supplied by manufacturer
  - Online

16 sections, examples:

2. Hazards
  - Physical
  - Health
  - Environmental
  - Other
4. First aid measures
5. Firefighting
6. Handling and storage
7. Exposure controls/PPE

Drawbacks?

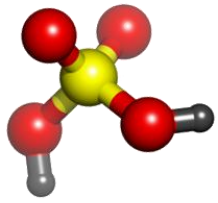


# GHS Safety Data Sheets (SDS)

- ▶ Drawbacks
  - Not always current
  - Lack of toxicity information for most chemicals
  - Industry focus, not specific to laboratory scale
  - Sometimes inconsistent

SDS contains comprehensive information for chemical management in one place

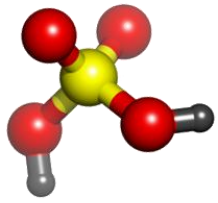
Keep SDS for each chemical in your inventory



# Module Overview: Fundamentals of Chemical Safety and Security

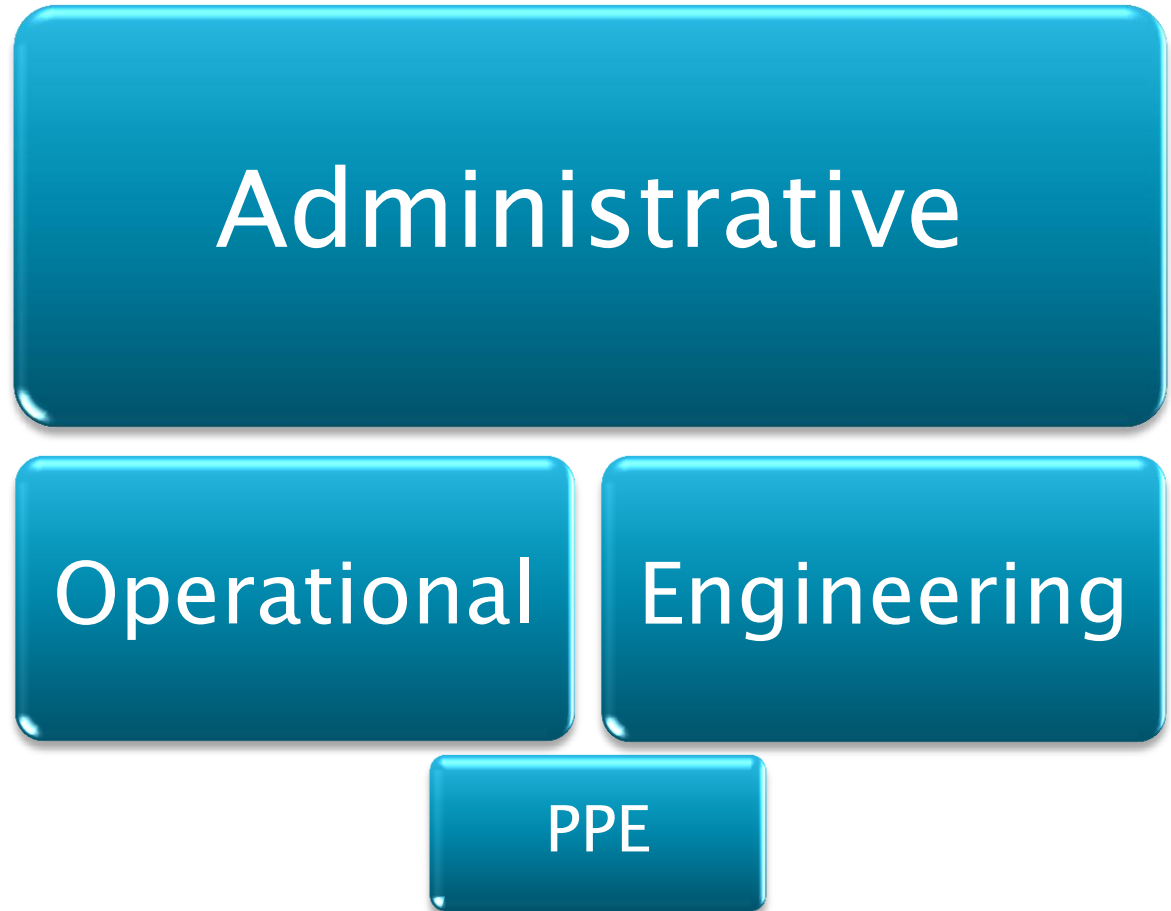
- ☑ Laboratory Hazards
  - ☑ Chemical
  - ☑ Physical
  - ☑ Biological
  - ☑ Radiological
- ☑ Globally Harmonized System (GHS) Hazard Labels
- ☑ GHS Safety Data Sheets (SDS)
- ▶ Hierarchy of CSS Controls
- ▶ Conclusions

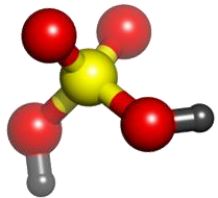




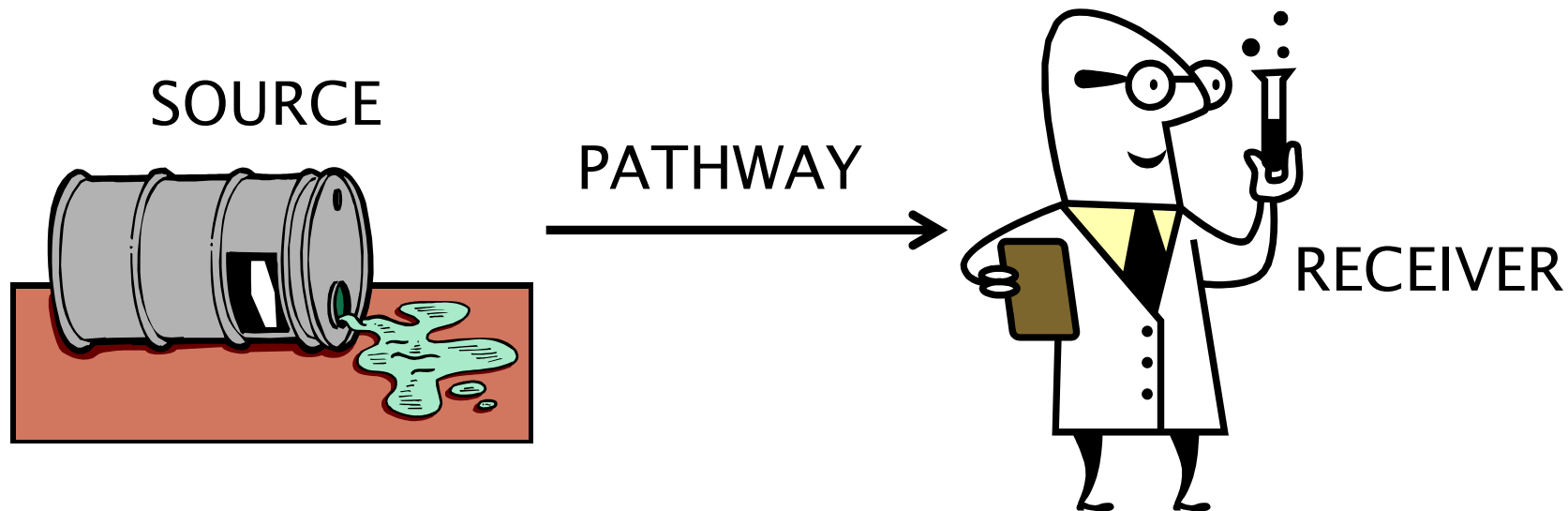
# Hierarchy of CSS Controls

- ▶ Purpose
  - Safety
  - Security
- ▶ Administrative
- ▶ Operational
- ▶ Engineering
- ▶ PPE



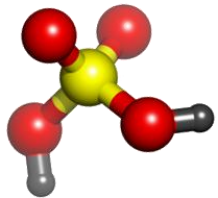


# CSS Controls: Safety Purpose

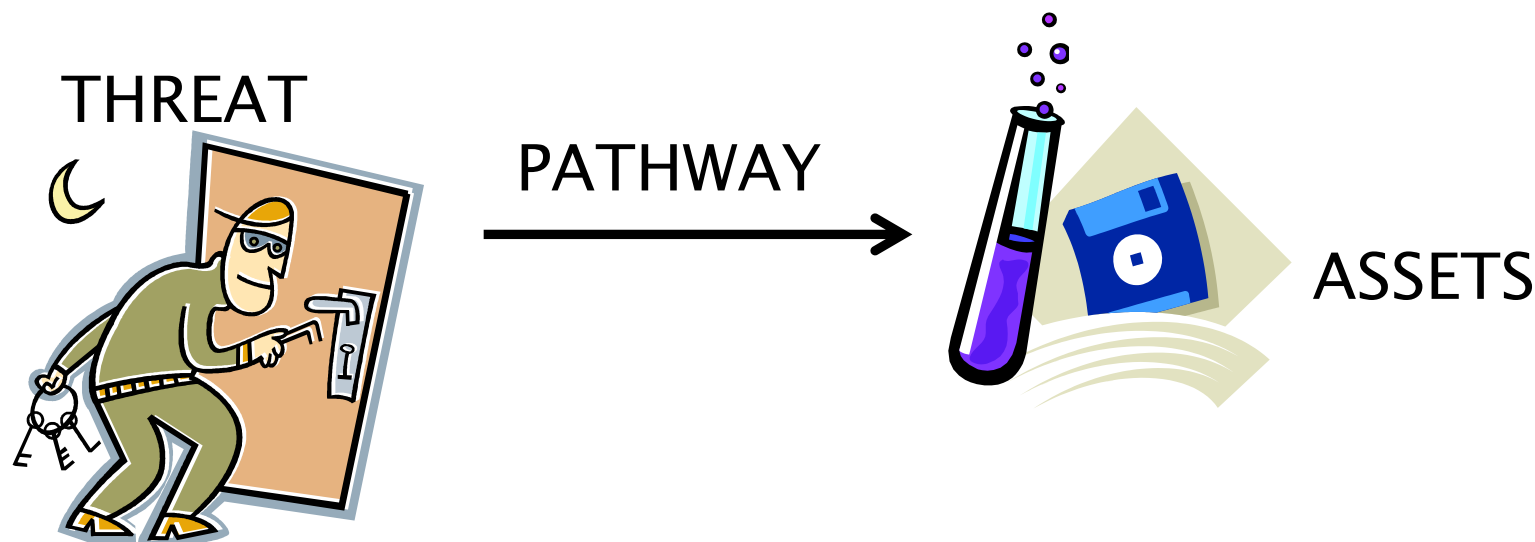


1. Eliminate the source
2. Block the pathway
3. Protect the receiver

**Chemical Safety Controls: Protect People from Chemicals**

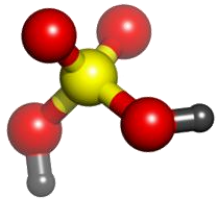


# CSS Controls: Security Purpose



1. Eliminate the threat
2. Block the pathway
3. Protect the assets

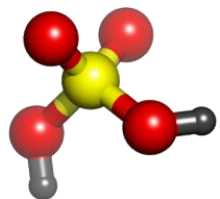
**Chemical Security Controls: Protect Chemicals (assets)  
from People**



# CSS Controls: Administrative

- ▶ Develop CSS policy
  - Communicate expectations regarding CSS
    - Prevent and mitigate CSS incidents
    - Build CSS into all operations
    - Comply with laws and regulations
    - Continually improve performance
- ▶ Implement CSS policy
  - Establish a CSS program
    - Assessments and reporting
    - Training
  - Appoint CSS personnel
    - Committee
    - CSS Officer
  - Provide resources and support
    - Incentives
    - Enforcement





# CSS Controls: Operational

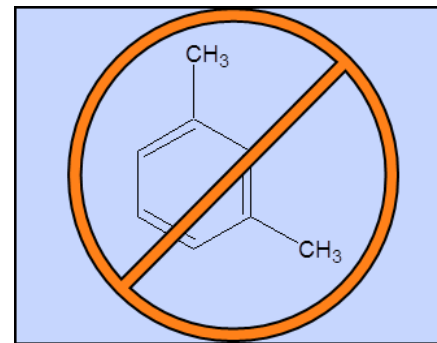
- ▶ Standard Operating Procedure (SOP)

- ▶ Substitution

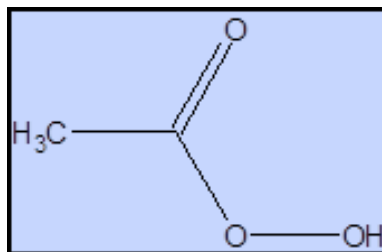
- Use a less dangerous chemical

- Alcohol thermometers instead of Hg

- Citrus-based solvents instead of xylene



- Peracetic acid instead of formaldehyde



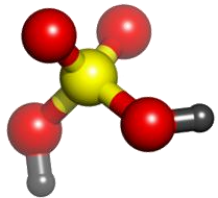
Administrative

Operational

Engineering

PPE





# CSS Controls: Operational

## ► Scale Down

- Procure and use a smaller amount of the dangerous chemical
  - Smaller cost
  - Smaller hazard
  - Easier to store
  - Easier to dispose



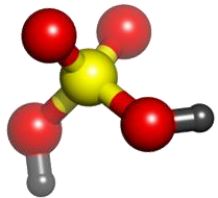
6<sup>th</sup> International Symposium on Microscale Chemistry, Kuwait, 2011  
[http://www.6ismc2011.com/images/welcome\\_img.jpg](http://www.6ismc2011.com/images/welcome_img.jpg)

Administrative

Operational

Engineering

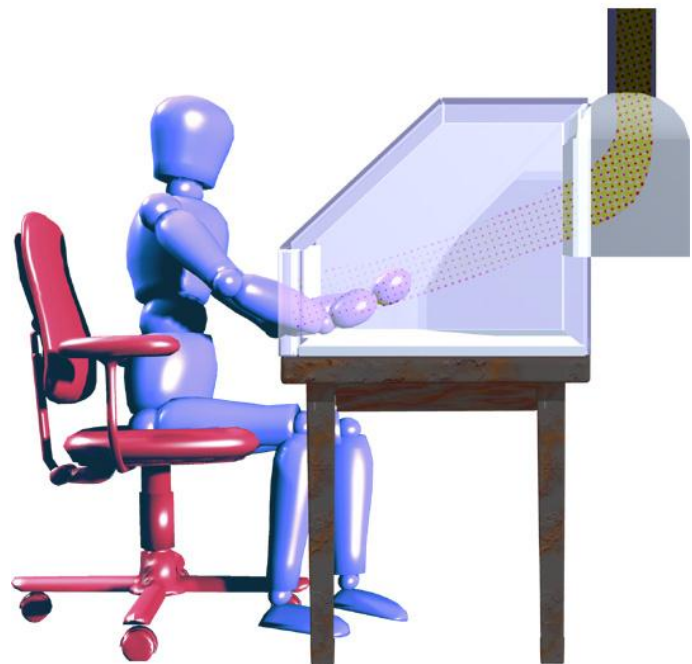
PPE



# CSS Controls: Engineering

- ▶ Isolate or enclose the process, hazardous material, or worker
  - Barrier (blast shield)
  - Ventilation (laboratory hood)
- ▶ Create barriers between threat and target
  - Control access to institution
    - Campus
    - Building
  - Lock laboratories and chemicals (especially COCs) when not in use

**Blocks the pathway from source to receiver, or threat to target**

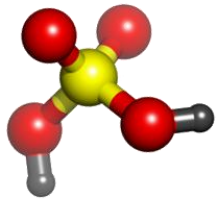


Administrative

Operational

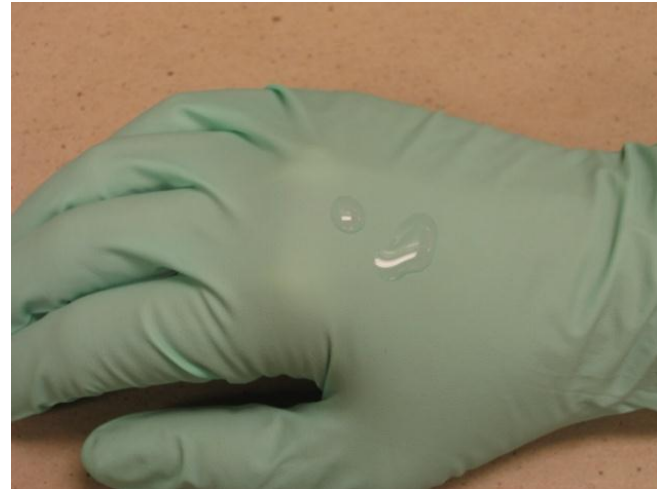
Engineering

PPE



# CSS Controls: Personal Protective Equipment

- ▶ Last line of defense
- ▶ For emergency or spill response
  - Glasses or goggles
  - Gloves
  - Laboratory coats
  - Respirators
  - Footwear
  - Eyewash and emergency shower
- ▶ Must be appropriate for the specific hazards



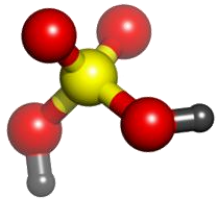
- ▶ Hanover New Hampshire, USA, 1996
- ▶ Prof. Karen Wetterhahn, Dartmouth College
  - Spilled a few drops of dimethylmercury on latex glove
  - Died 6 months later

Administrative

Operational

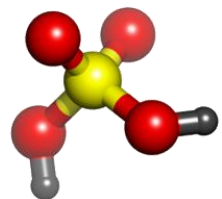
Engineering

PPE



# Conclusions: Fundamentals of Chemical Safety and Security

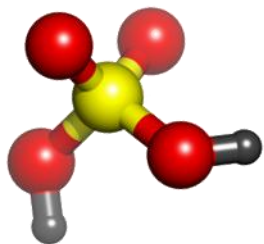
- ▶ Recognizing laboratory hazards is an important first step in improving CSS
- ▶ Appropriate CSS controls are based on the hazards



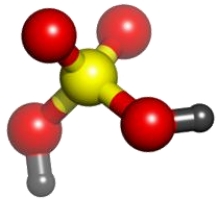
# Workshop Overview

- ☑ Orientation to Chemical Safety and Security (CSS)
- ☑ Fundamentals of CSS
- ▶ Chemical Management
- ▶ Workshop Summary and Conclusions



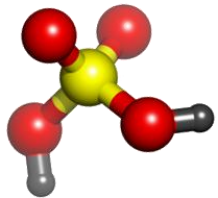


# Chemical Management



# Overview: Chemical Management

- ▶ Cradle to Grave
- ▶ Procurement
- ▶ Storage
- ▶ Inventory
- ▶ Activity: Standard Operating Procedures (SOPs)
- ▶ Waste
- ▶ Conclusions, Benefits of Best Practices



# Cradle to Grave

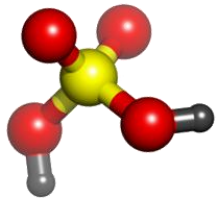
- ▶ Control and accountability of chemicals at all times, from procurement to disposal as waste



Procurement → Storage → Use

Disposal





# Procurement

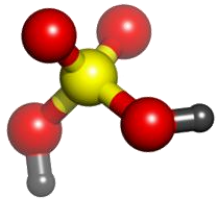
## Planning is Key

- ▶ Think “Cradle to Grave” before purchasing or accepting chemicals
  - What chemicals are needed?
  - How much are needed?
  - How/where will they be stored?
  - How will they be handled/used?
  - How will disposal take place?

**“Extra” chemicals are not usually a good idea**

**Donated chemicals are not always “free”**



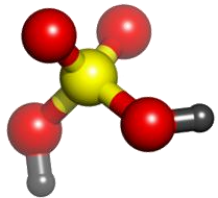


# Storage

- ▶ Activity: Chemical Storage
- ▶ General Guidelines
- ▶ Compressed Gas Cylinders
- ▶ Examples
- ▶ Access Control





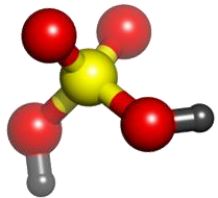


# Activity: Chemical Storage

- ▶ Find one or two partners
- ▶ Use the hazard and compatibility information to optimize chemical storage
- ▶ Rules:
  - 4 bottles per shelf maximum
  - Note that only one cabinet has a vent
  - Only one cabinet can be secured (padlock)

**You may have to make some compromises or hard choices**

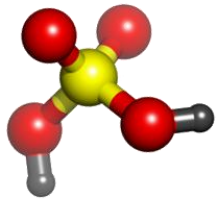
- ▶ When finished, discuss the following and write comments in your workbook:
  - Was there one “perfect” way to store the chemicals?
  - Did you have to make compromises? What were they?
  - In making compromises, what were your main priorities?



# Activity: Chemical Storage

## Conclusions

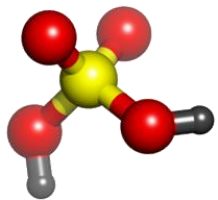
- ▶ Can make chemical storage safer and more secure
- ▶ Safe and secure chemical storage requires
  - Space
  - Time
  - Training
  - Equipment
- ▶ Difficulties may be mitigated by operational controls
  - Substitution
  - Scale Down



# Storage: General Guidelines

- ▶ Separate incompatible chemicals
  - Organize by groups
  - Alphabetize only within groups
- ▶ Separate flammables and explosives from ignition sources
  - flammable storage cabinets
- ▶ Large containers on bottom shelves
- ▶ All containers properly labeled and closed

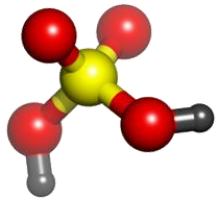




# Storage: General Guidelines

- ▶ Wipe-off outside of container before returning to storage area
- ▶ Use secondary containment
  - Label with compatibility group
- ▶ Fasten storage shelves to wall or floor
- ▶ Shelves should have a lip and/or rod





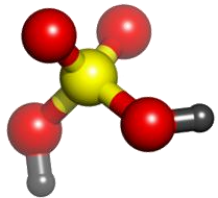
# Storage: General Guidelines

## ▶ Do Not Store Chemicals

- On top of cabinets
- On the floor
- In hoods
- In hallways
- With food
- Where there are wide variations in temperature, humidity, or sunlight



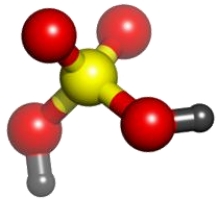




# Storage: Compressed Gas Cylinders

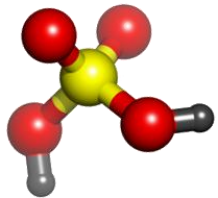
- ▶ Store in well-ventilated area away from direct sun
- ▶ Keep from being knocked over
- ▶ Screw down cylinder caps
- ▶ Separate incompatible gases





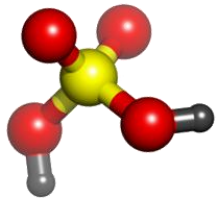
# Storage: Examples





# Storage: Access Control

- ▶ Access limitations depend on the material or information
  - More control of access if COCs are present
- ▶ Lock areas, rooms, cabinets
  - Control of keys
- ▶ Label areas “Authorized Personnel Only”
  - Means of identifying authorized personnel
    - Challenge unfamiliar people in restricted areas
- ▶ Authorized personnel
  - Trusted, background check
  - Trained
  - Legitimate need



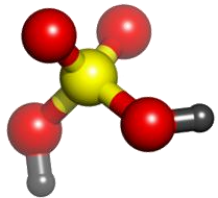
# Inventory

- ▶ Database of chemicals
  - Computer/web-based
    - Barcodes
  - ID, location, owner, hazards
- ▶ Control access to database
- ▶ Maintain with inspections
- ▶ Ensure control and accountability
  - No orphan chemicals



- ▶ Benefits
  - Saves time
  - Improves research
  - Improves safety
  - Improves security
  - Saves money
  - Regulation compliance
  - Earn recognition

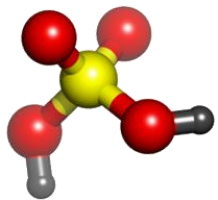




# Overview: Chemical Management

- ☑ Cradle to Grave
- ☑ Procurement
- ☑ Storage
- ☑ Inventory
- ▶ **Activity: Standard Operating Procedures (SOPs)**
- ▶ Waste
- ▶ Conclusions



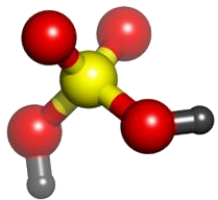


# Activity: Standard Operating Procedures (SOPs)

- ▶ SOP: A set of steps for carrying out a laboratory task
- ▶ Scenario: You are a chemist in a Quality Control (QC) lab
- ▶ Goal: Develop an SOP for preparing a standard acid solution for titration
- ▶ Get in groups of 4–5 people per group



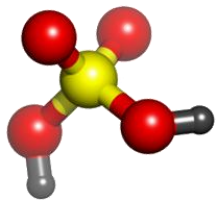
Buret photograph courtesy of Indigo® Instruments








# Activity: Standard Operating Procedures (SOPs)

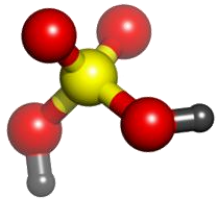
- ▶ Refer to the SDS for  $\text{H}_2\text{SO}_4$ , and the partially completed SOP
- ▶ In your groups, discuss
  - Hazards
    - Chemicals, reactions, and products
    - Equipment
    - Storage
    - Disposal
    - Security
  - Controls
    - Operational
    - Engineering
    - PPE
- ▶ Fill in the blanks to complete the SOP
  - Be prepared to discuss with the whole group





# Activity: Standard Operating Procedures (SOPs)

Hazards in this SOP	
Preparation of solutions	 
Equipment	 
Waste/disposal	
Security	

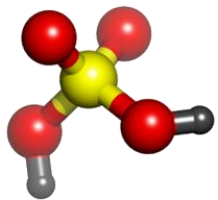


# Activity: Standard Operating Procedures (SOPs)

## Controls?

- ▶ Operational
  - SOP
  - Substitution
  - Scale down
- ▶ Engineering
- ▶ PPE
  - Quantity dependent

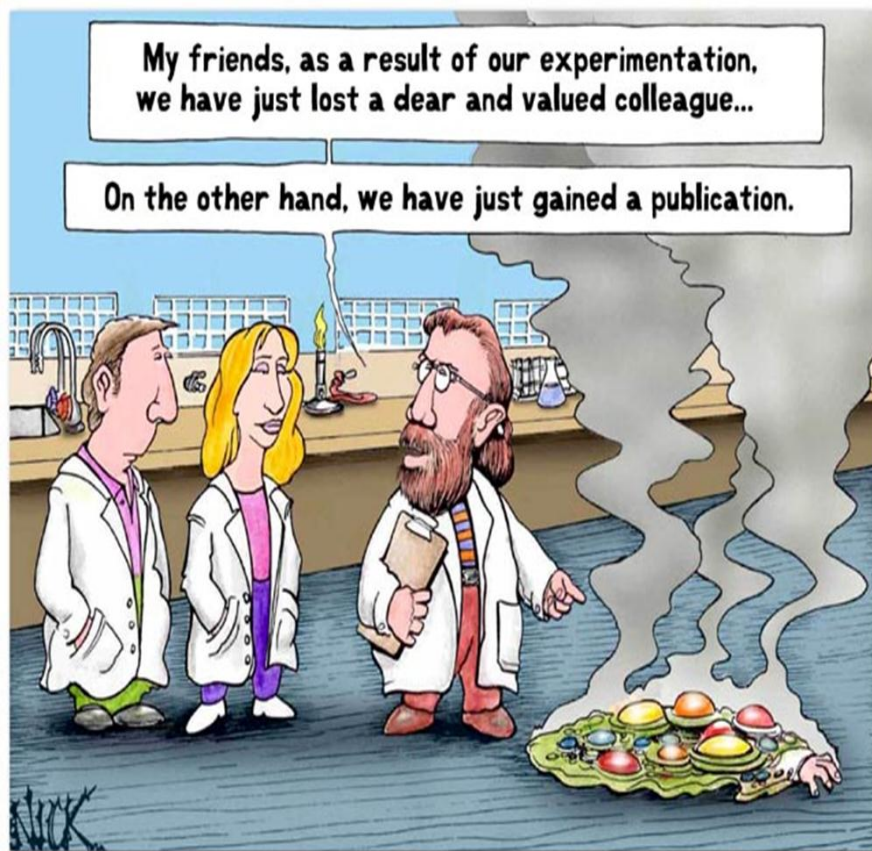




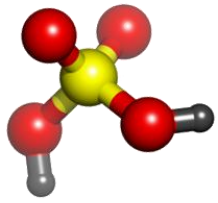
# Activity: Standard Operating Procedures (SOPs)

## Conclusions

- ▶ SOP is a set of steps for carrying out a laboratory task safely and securely
- ▶ Should be part of a formal training procedure
  - Update regularly
- ▶ Protects students/workers, faculty, administrators, chemicals/info



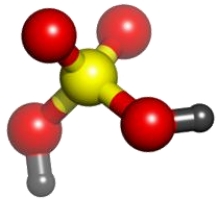




# Waste

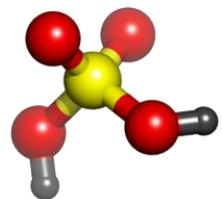
- ▶ Plan ahead
  - Minimize amount and hazards
- ▶ Separate during collection and storage
- ▶ Recycling and/or disposal
- ▶ Prevent orphans and unknowns





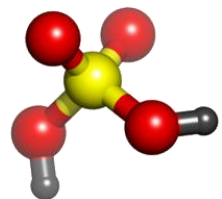
# Conclusions: Chemical Management

- ▶ Key to chemical safety and security
- ▶ Involves all CSS controls
  - Administrative
  - Operational
  - Engineering
  - PPE
- ▶ Many issues addressed by planning ahead
- ▶ Best practices in chemical management and high quality research are positively correlated
- ▶ Opportunities for those willing to pioneer improvements



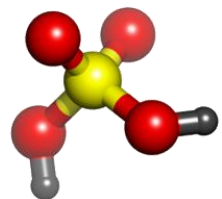
# Workshop Summary

- ☑ Orientation to Chemical Safety and Security (CSS)
- ☑ Fundamentals of CSS
- ☑ Chemical Management
- ▶ Workshop Summary and Conclusions



# Workshop Conclusions

- ▶ Promote the safe and peaceful use of chemistry
- ▶ Appreciate the importance and benefits of Chemical Safety and Security (CSS)
  - To do top level work, you need top level CSS practices
- ▶ Encourage the creation of networks of people interested in CSS
  - Culture of Chemical Safety and Security



# Closing Remarks

